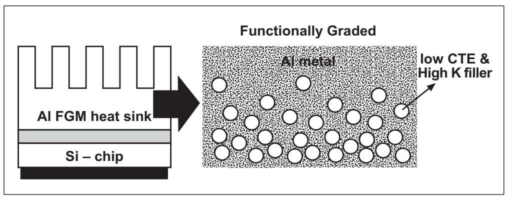
service conditions. Previous composite evaluations have been largely post-failure analyses and of marginal utility to the design community. Now with basic research advances from three university research programs, engineers will be able to uniquely optimize composites. The AFOSR-funded university researchers are integrating experimental and computational methodologies to characterize the complex nature of structural responses and damage modes of composite materials.

Next-generation military aircraft designers are making ever-increasing demands for higher performance materials. Composites offer significant advantages to affordably satisfy these emerging demands. The basic research accomplishments and insights from these research programs will enable the development of life-prediction tools for composites and provide the confidence required to expand the use of high performance, high efficiency composite materials in critical components such as wings, propellers, and engine fan blades.

HIGHER TEMPERATURE PERFORMANCE AND STABILITY

Dr. Minoru Taya of Washington University has developed a method to optimize a composite structure's thermal conductivity by adjusting its density and composition.



ABOVE: Higher Temperature Performing Composites. Structural material designers will be able to optimize a composite's thermal conductivity by adjusting its density and composition.

The ability of a specific composite material to dissipate heat while maintaining a desired degree of conductivity can be manipulated by varying the volume and type of material used as filler. Such flexibility allows a designer to match the composite's coefficient of thermal expansion to that of an electronic chip or diode and minimize thermal stress at the interface. This research is leading to increased composite use in military electronic circuitry and has attracted the attention of the electronic packaging industry including, Johnson Matthey Electronics (a major supplier of interconnect materials) and Intel Packaging Group.

ACCURATE DAMAGE EVOLUTION AND LIFETIME PREDICTION

Drs. Thomas Mackin and Nancy Sottos, of the University of Illinois are applying infrared imaging and micromechanics to provide detailed analysis of damage evolution and its relation to composite microstructure.

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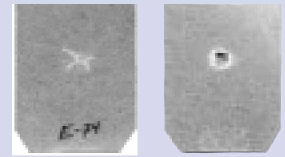
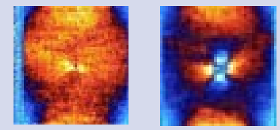
Photographic versus Infrared Images of Damaged Composites

BELOW: Photographic images of glass fiber-reinforced epoxy composite test samples after 2 types of impact damage



Partial Impact Penetration

Full Impact Penetration Punctures Material



Using an infrared imaging method (color photos above), researchers can precisely measure and quantify surface stresses (using a color scale) which escape optical detection in damaged composites. The lighter the color, the higher the stress as indicated in the vicinity of the impact areas. This new imaging tool can be used to trace the evolution of damage. Knowing how to quantify impact damage (ex: hail, dropped objects, birdstrikes, bullets) will allow the Air Force to predict the remaining lifetime of composite materials and to determine whether and when to replace them.

fits Research Tied to Air Force Tactical Operations

Force will be better able to detect missiles during boost phase. Molecular recombination within and around the rocket exhaust plume can yield specific signature information that could be exploited to enhance detection capabilities. This research will also improve the detection of objects — satellites, warheads, missiles — re-entering the atmosphere. During re-entry, objects are surrounded by plasma — the flow field created by atmospheric friction. As the understanding of flow fields and the accompanying molecular recombination improves, better detection systems will be developed. Neutralization of flow fields to avoid enemy detection or to maintain communications during manned re-entry may also become feasible.

Dr. Flannery's research has broader implications as well, including how pollutants influence atmospheric recombination. Because of his work and similar research, new methods of effectively dealing with environmental problems will be developed. As members of the world community, the U.S. military is interested in maintaining a strongly proactive environmental stance.

The AFRL Propulsion Directorate (AFRL/PR) is also interested in the applications of Dr. Flannery's work. His theoretical research will aid in under-standing interactions that take place in plasma deposition and etching, the processes often used in manufacture of large-scale integrated circuits. AFRL/PR is conducting research into the formation of dust in plasmas, a process that can interfere with deposition and etching.

AFOSR is the sole sponsor of Dr. Flannery's research on molecular recombination.

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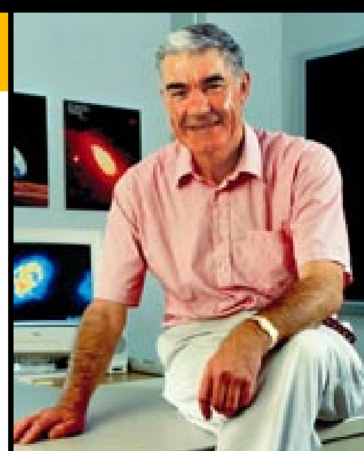
For more information about Dr. Flannery, visit our website at: www.afosr.af.mil or proceed to page 5



Dr. Raymond Flannery

1998 Recognition as World-Class Researcher

- Received American Physical Society's 1998 Will Allis prize
- Inducted as worldwide honorary member of Royal Irish Academy
- University of Belfast confers honorary Doctor of Science degree